IMAGING, MODELING, MEASURING, AND SCALING OF MULTIPHASE FLOW PROCESSES

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OBJECTIVE

Our objective is to develop methodologies based on advanced imaging technology for rapid and accurate measurement of petrophysical properties and prediction of engineering parameters needed for reservoir simulation.

APPROACH

To simulate multiphase flow in a reservoir, for the various facies, one needs to know petrophysical parameters such as porosity, permeability, relative permeabilities, and capillary pressures. Laboratory measurements of these parameters using core plugs are often expensive, time consuming, or unavailable because of a lack of core material. Thus, the need exists to develop rapid methods that require a minimum of core material. One promising approach uses pore-network models to compute rock properties. This project addresses (1) obtaining pore-network data to be used as input for existing network models, (2) validating the network predictions with laboratory core measurements, and (3) upscaling the core measurements to use in field simulation. The work emphasizes extracting the pore data needed for network modeling from synthetic sedimentary models constructed from grains, using grain-size distribution extracted from analysis of small reservoir rock samples not amenable to regular core-flooding techniques. This approach permits setting the spatial resolution to levels not obtainable experimentally from microtomography, but which are needed to resolve the pore throats in many rocks of economic interest. It also presents a very significant time and cost advantage compared to microtomography.

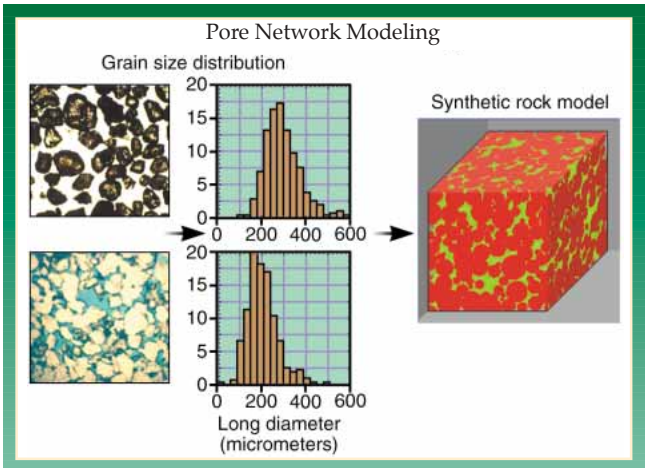

Figure 1. Synthetic sedimentary model of sandstone, based on grain data

ACCOMPLISHMENTS

A synthetic sedimentary model was used to construct 3D pore networks based on grain-size data obtained from digitized images of grains (in turn obtained from thin sections). The software package 3DMA from the State University of New York, Stonybrook, was used to extract pore-network parameters from 3D images of pore space. The extracted data were used as input in the pore-network model ANETSIM to calculate relative permeability and capillary pressure curves. The network simulations for drainage-water-oil relative permeability and capillary pressure showed good agreement with experimental data. We also completed the development of the quasi-static simulator of drainage and imbibition. To provide the ability to image the pore structure of many rocks that are of critical economic importance to oil and gas production, and to increase the basic understanding of pore-scale processes, we are involved in a cooperative project to construct a submicron-resolution rock-microtomography imaging capability at the Advanced Light Source. Also, using x-ray computer-tomagraphy imaging at the new Rock-Fluid Imaging Laboratory, we investigated foamy oil production and the effect of saturation on wave attenuation.

SIGNIFICANCE OF FINDINGS

By reducing the cost and time of petrophysical core measurements, the density of petrophysical data can be significantly increased. This higher data density, combined with proper upscaling, will yield more accurate reservoir simulations, improved oil-reservoir management, and increased oil recovery.

RELATED PUBLICATIONS

Patzek, T.W., Verification of a complete pore network simulator of drainage and imbibition, SPE 71310, SPEJ, 6, 2144–2156, June 2001.

Liu, Z., K.T. Nihei, L. Tomutsa, L.R. Myer, and J.T. Geller, Sonic - frequency attenuation in partially saturated, unconsolidated sand, presented at American Geophysical Union 2000 Fall Meeting, San Francisco, California, Dec. 15–19, 2000.

Liu, Z., J.W. Rector, K.T. Nihei, L. Tomutsa, L.R. Myer, and S. Nakagawa, Extensional wave attenuation and velocity in partially saturated sand in the sonic-frequency range, Accepted for presentation at the 38th U. S. Rock Mechanics Symposium "Rock Mechanics in the National Interest," July 7–10, Washington, D.C., 2001.

ACKNOWLEDGMENTS

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